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Design TPACK Strategy with Modellus Software for Simulation Based on The Guided Inquiry on The Wave Concept

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Abstract

Technological Pedagogical and Content Knowledge (TPACK) is a teacher framework in integrating Information and Communication Technology (ICT) in learning. The purpose of the initial learning planning by implementing the guided inquiry-based TPACK strategy is to increase the mastery of concepts and student learning activities. This research uses the literature review method with qualitative predictive analysis. Object research is an information system with the reason that there is a change in the application of information systems that were once still conventional, now began to be computerized and the development of information systems can be on various platforms, Among others, the web, desktop, mobile, and the last reason being that the development of information system systems has a variety of methods. Initial planning of learning using TPACK-based guided inquiry effectively improves students' mastery of concepts. The subjects were transversal and longitudinal waves with Modellus software. In general, this initial design is that learning with guided inquiry-based TPACK strategies increases mastery of concepts and student learning activities.

Keywords: Inquiry; Modellus; Wave; TPCK

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INTRODUCTION

Physics is one of the branches of science that is the basis of advanced technology development. Physics is considered a hard lesson due to its complex formulas (Bakri & Muliyati, 2018; Billah et al., 2016) ; Muzaky et al., 2020). More than half of students (56%) dislike physics learning. The lack of students enjoying the teaching of physics is what causes low interest and low activeness in studying the physical sciences. It will impact the lack of understanding of students. The low interest and understanding of students towards physical learning may be due to the lack of ability of teachers to streamline the practice of pedagogy (teaching science) and mastering subject matter (content) by integrating technology in the learning environment. The shortage of students enjoying physics learning causes low interest and low activeness in studying physics. Integrating technology in the learning environment will impact students' lack of understanding-mastering subject matter (content) (Putriani, 2014).

The learning process that integrates technology is not easy because most teachers still stutter technology because there are still few teachers who use technology. Seen from as much as 35% of Banjarmasin City Junior High School teachers have good ability to use ICT in school. Then 20% of its ICT capabilities are just enough or moderately. The remaining 45% of teachers do not understand or never use ICT in learning (Mansur et al., 2020).

The severe challenge faced by the world of education in Indonesia in the global complex is teachers' ability to design teacher competency development planning called Technological Pedagogical Content Knowledge or TPACK. TPACK is a comprehensive integration of knowledge and skills in material terms and pedagogy combined in technological developments. TPACK was first created by Shulman (1987) and developed by Koehler & Mishra (2008). TPACK is considered a potential framework that can provide a new direction for teachers in solving problems related to integrating ICT into classroom teaching and learning activities (Suyamto et al., 2020).

Based on the results of the research data processing, it can be concluded that the application of generative learning models with the TPACK framework can improve student learning outcomes in substance material and changes in class VII MTs Nahdhatul Atfhal Sungai Ambawang. As for the results obtained as follows: (1) Student learning outcomes on substance material and its changes before applying generative learning models with TPCK framework obtained an average of 48.00 with pretty good criteria; (2) Student learning outcomes in substance material and changes after applying the generative learning model with the TPCK framework are obtained an average of 72.96 with good (Boisandi, 2019).

One form of implementation of the TPACK framework is learning devices using Modellus, which is one of its functions to focus the learning process on relevant physics and mathematics. Modellus is used to introduce a computing model that allows easy creation of a physics model that only uses standard physics notation. Then Modellus can create animations with objects that have interactive properties expressed in mathematical models and allow exploration of multiple representations and allow the analysis of experimental data in the form of drawings, animations, graphics, and tables. Modellus is suitable for the learning process of physics with the advantage of being able to trace the phenomenon of physics and find a mathematical relationship that builds the physical phenomenon (Jonny et al., 2020).

Integrating technology in learning using simulation media (Modellus software) hopes students had not quickly saturated in learning physics. Simulation media (Modellus software) is expected to make it easier for students to learn physics, improve, increase interest in studying the physical sciences, and make them more active.

METHOD

The search process obtains sources relevant to the researcher's title and other related references. The search process is carried out using a browser with various journals that have been licensed and from international journals and national journals.

The data set studied a journal that discusses learning using TPACK strategies focused on learning media with information technology from 2018 to 2021. The systematic literature review (SLR) method identified the data as being applied. SLR Method can be systematically reviewed and identified journals in each process, following the rules in every step or protocol set (Kitchenham et al., 2009). This SLR method can also avoid subjective identification, and it is hoped that the results of its identification can add to the literature on the use of the SLR Method in journal identification (Triandini et al., 2019).

The data set studied journals that discussed the learning process using TPACK strategies that focus on learning media with information technology from 2018 to 2021. Data collection is the stage at which data for research is collected. The data collected in this study are primary and supporting data.

Research questions or research questions are made based on the needs of the selected topic. Here are the research questions in this study: "What journal titles will be used as reference material (TPACK guided inquiry, modellus, learning outcomes?" The search process is used to get relevant sources to answer research questions and other related references. The search process is done using search engines (Google Chrome) with Google scholar or Scopus site addresses or other online journal addresses.

This stage is done to decide whether the data found is worth using in this study. Studies are worth selecting if there are the following criteria: (1) Data used in the period 2018-2021; (2) Data obtained through Google Scholar or Scopus or other online journal addresses as support; (3) The data used relates only to TPACK, guided inquiry, modellus, learning outcomes.

Quality Assessment

In the SLR study, the data will be evaluated based on the following quality assessment criteria questions: (1) Will journal papers be published in 2018-2021? (2) Is it in the journal paper that the information of TPACK, guided inquiry, Modellus, learning outcomes?

RESULT AND DISCUSSION

Student worksheet inquiry given to students aims to so that students can understand the concept well by finding themselves with the guidance of teachers without teachers as a learning centre. And the existence of the TPACK strategy is applied by utilizing the media simulation software Modellus. The students become more enthusiastic in learning the physics defence and play an active role in finding the concept of material discussion of vibrations and waves (Ilmi et al., 2020). In addition, improving students' activeness of this TPACK strategy also aims to enhance student competence in understanding in terms of cognitive learning outcomes, especially in students towards vibration and wave material.

Teachers' stage in implementing the TPACK strategy is to demonstrate the waveform by using ropes and slinks as the initial stage in introducing wave types. After that, the teacher gave LKPD about the wave material to students and gave a partial demonstration of Modellus software. Then students operate learning media using computer technology in Modellus software applications in which there is a simulation of the course of transverse and longitudinal waves. After students find their answers to the question of worksheet inquiry given by the teacher, they understand the concept of vibration and waves and dare to present the results of their discussions (Harris, et al. (2009) mention the characteristics of TPACK to improve the understanding of the concept and foster the activeness of students' learning. Teachers identify learning objectives, consider the context and model of education, choose the appropriate learning stages, selecting and learn various suitable tests. They also select ICT tools to follow the learning objectives and subject matter and analyze students' data. Teachers reflect on the learning activities to improve the following learning process. Teaching and learning activities by utilizing computers as a learning support technology enhance understanding of student concepts. This finding happens because they remember the concept of material that they found themselves. Computer use turns students are more excited in learning activities as they discover new ways of learning by utilizing computer technology. There are vibration animations and wave simulations that provide more understanding.

TPCK strategy applied in the form of utilizing simulation media using this Modellus software appeals to students. The learning media used has the advantages of easily understood material content, quizzes and examples of questions, and buttons that facilitate operation. These learning outcomes are in line with the author's findings (Mayer & Girwidz, 2019; Thohir & Warsono, 2018). It is an advantage because students are more excited about learning. The activeness of student learning increases and can also improve the understanding of concepts because students actively find their concepts on vibrations and waves. In addition to providing liveliness and knowledge of students, this TPACK strategy also positively affects students, making it easier to memorize wave formulas and facilitate memory in longitudinal wave images and transverse waves. Of course, even at the first meeting, students are still in a state of confusion. But after the meeting, the two students understood for themselves. Implementing this TPCK strategy has the power and appeal to foster active student-focused learning.

Learning Strategy

Technological Pedagogical and Content Knowledge (TPACK)

Technological Pedagogical and Content Knowledge (TPACK) is a framework to understand and describe the type of knowledge. The teacher needs this concept to make pedagogical practice and concept understanding effective by integrating technology in the learning environment. The idea of pedagogical content knowledge (PCK) by Shulman (1986) and TPACK is based on the main idea through technology coverage. Mishra et al. (2020) have done extensive work to build the TPACK framework (Oliver 2011).

TPACK is formed from a combination of 3 types of basic knowledge, namely Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK). The results of the combination of these three essential pieces of knowledge produce four new knowledge, including Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK).

Technological knowledge (TK) is knowledge about various types of technology as tools, processes, and resources. Pedagogical knowledge (PK) is knowledge of theory and practice in planning, process, and evaluation of learning. Content knowledge (CK) is knowledge about content or subject matter that teachers must study and teach to students. Pedagogical content knowledge (PCK) is pedagogical knowledge related to specific content.

Technological content knowledge (TCK) is knowledge about the interchange between technology and content. Technological pedagogical knowledge (TPK) is knowledge about various technologies used to facilitate learning and learning. TPACK is

knowledge to use appropriate technology in appropriate pedagogics and teach content well. These seven pieces of knowledge need to be mastered by future teacher candidates who will teach in a learning environment filled with various technological instruments. So that teachers can use the right technology in appropriate pedagogics for the specific well.
Search process results are displayed in Table 1.

Table 1 Journal-title data

No	Journal
1	The development of 21st-century skills and competence in-service teacher through TPACK training workshop. AIP Conference Proceedings (Vol. 2320, No. 1, p. 020032). AIP Publishing LLC.
2	The Scientific Cues Study of "Zarrah" in Al-Qur'an as Knowledge Content on Modern Physics Learning Based on Track. 'Abqari Journal, 23(1), 1-14.
3	Transverse-wake wave breaking. *Physical review letters*, 78(22), 4205.
4	Wave-induced vibration control of offshore jacket platforms through SMA dampers. Applied Ocean Research, 90.
5	Longitudinal and Transverse Thrust. Journal of the Society of Naval Architects of Japan, 2000(187).
6	Development of TPACK based-physics learning media to improve HOTS and scientific attitude. Journal of Physics: Conference Series, 1440(1).
7	Physics Teachers' Acceptance of Multimedia Applications—Adaptation of the Technology Acceptance Model to Investigate the Influence of TPACK on Physics Teachers' Acceptance Behavior of Multimedia Applications. Frontiers in Education, 4.
8	Evaluating students logical thinking ability: TPACK model as a physics learning strategy to improve students logical thinking ability. Journal of Physics: Conference Series, 1511(1).
9	Instructional Technology: Teacher's Initial Perception of TPACK in Physics Learning. Jurnal Penelitian & Pengembangan Pendidikan Fisika, 6(1), 131-138.
10	*Handbook of technological pedagogical content knowledge (TPCK) for educators*. Taylor & Francis.
11	Implementation of TPCK Strategy With Inquiry-Based Simulation Media Guided on Vibration and Wave Concepts. *UPEJ Unnes Physics Education Journal*, 3(2).
12	Analysis of TPACK Ability (Technological, Pedagogical, And Content, Knowledge) High School Biology Teacher in Compiling Circulatory System Material Learning Devices.
13	Designing Optical Spreadsheets-Technological Pedagogical Content Knowledge Simulation (S-TPACK): A Case Study of Pre-Service Teachers Course. *Turkish Online Journal of Educational Technology - TOJET*, 17(1), 24-36

System Development Life Cycle (SDLC) or methodology *Structured Systems Analysis & Design* (SSAD) The shortcomings of this SSAD method are: (1) SSAD is primarily process-oriented, thus ignoring non-functional needs; (2) Very little management is directly related to SSAD; (3) The basic principle of SSAD is the development of non-iterative (waterfall), but the need will change in each process; (4) In addition to using logic and DFD designs, not enough tools are used to communicate with users, making it very difficult for users to evaluate; (5) SSAD does not always meet the needs of users.

Wave

Waves are propagating vibrations; wave motion can be viewed as the movement of momentum from one point in space to another without moving through a medium which can be solid, liquid or gas. Waves based on the medium of propagation can be categorized into mechanical waves and electromagnetic waves (Kanginan, 2017). Mechanical waves consist of particles that vibrate, in their propagation requires a medium. Based on the direction of vibration and the direction of propagation. Waves are divided into two types, namely transverse waves and longitudinal waves. Transverse waves (see Figure 1) are waves whose direction of propagation is perpendicular to the direction of vibration, for example, waves on a rope, water surface waves, light waves (Enferadi et al., 2019; Fujikubo et al., 2000).

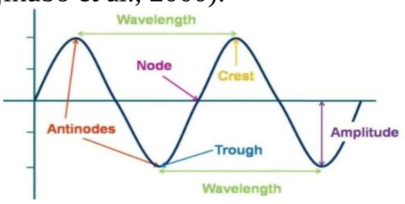

Figure 1 Transverse wave

While longitudinal waves (see Figure 2) propagate in the same direction as the direction of vibration, for example, sound waves and spring waves, a longitudinal wave consists of compression and strain (Bulanov et al., 1997; Shen et al., 2014). Density is areas where the coils approach for a moment. Strain is the area where the coils move apart for a moment. Density and strain correspond to the crests and troughs of a transverse wave.

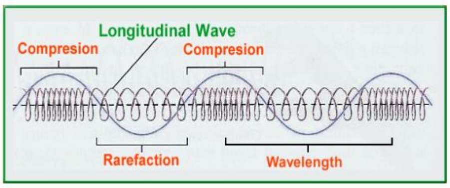

Figure 2 Longitudinal wave

The quantities used to describe waves include wavelength, the distance between two successive peaks, frequency (f) is the number of waves that pass a point per unit time, and period (T) is the time it takes for a wave to pass a point. Amplitude (A) is the maximum deviation from the equilibrium point, wave speed (v) is the speed at which the crest of the wave (or another part of the wave) travels.

Models Simulation

Search process results have been referring to using learning simulations in the data. However, there is no referring to Modellus software simulations in these journals, so researchers provide solutions by designing learning by providing examples of simulation guides using Modellus software simulations. Here's a guide that can be given to students.

To create wave model simulations, follow the steps for following steps

1) Prepare the Modellus software, then enter the variables and formulas in the mathematical model.
2) For writing, equations are written using the formula equation.
3) Then "enter". After entering, we write it according to the following Figure 3.

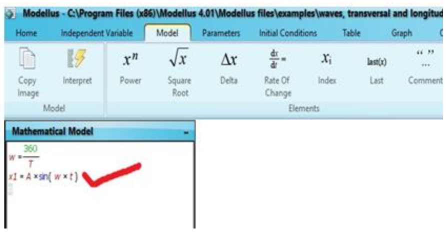

Figure 3 Next formulae

4) Then enter again and rewrite the equation using the model on the menu.

   and then write the equation of the formula with the following arrangement

$$x2 = \begin{cases} 0, & t \leq \frac{d}{v} \\ A \times \sin\left(w \times \left(t - \frac{d}{v}\right)\right) \end{cases}$$

5) Then enter, after filling in the equation x up to x = 24, at t is replaced with n variables.
6) After all the formulas are written, we will create the object by selecting the "objects" menu selecting the particle. If we make a particle-wave simulation, choose the horizontal coordinate with 0.0 and the vertical coordinate with the x1 option. Create object particles up to 24 (for each coordinate axis on the particle, fill in the horizontal coordinates with 0.0 and vertical coordinates with x1, x2,…, xn).
7) Then set it on the "Parameter" menu with the specific conditions.
8) After all the procedures above are done, as shown in Figure 4.

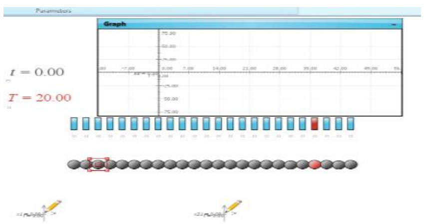

Figure 4 Entering the parameter

9) Then press the play button. It will be as Figure 5.

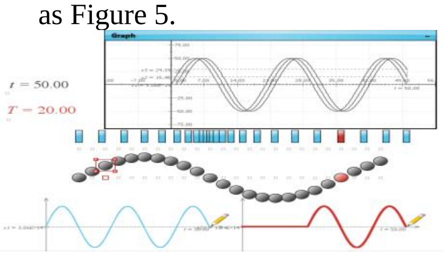

Figure 5 After running the simulation

10) For longitudinal waves only by changing the object into a vertical rectangle, the horizontal coordinates are selected with x1,x2,..., xn (on the nth particle) and on the vertical coordinate axis is filled with 30.00. Longitudinal wave simulation as Figure 6.

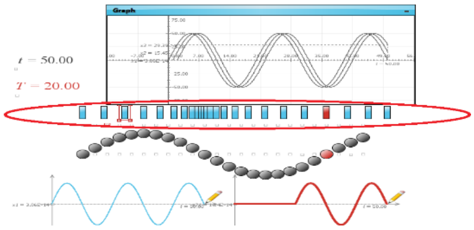

Figure 6 The final simulation

CONCLUSION

The challenges of the 21st century are providing solutions to teachers who stutter technology by providing learning simulations in the form of software guidance models on wave material. That is with the initial plan of design guide simulation software. I hope that teachers who are still stuttering technology can easily use this software simulation media. This software device is famous for with modellus.

Modellus makes it easy for students to use mathematical equations on physics topics, especially vibrations and waves. The Modellus also displays a graph of the relationship between time and wave mileage. The variables included in the vibration and wave equations are time (t) and mileage (x). The results obtained in the form of numbers are displayed in the Table box. Calculations using Modellus and equations of results are the same, but calculations with Modellus are more accurate than manual calculations. Modellus software by combining this guided inquiry learning model can make it easier for students to understand the concepts of vibration and waves, making students dare to present the results of their discussions. In addition to providing student liveliness and understanding, this TPACK strategy also positively impacts students, making it easier for students to memorize wave formulas. And facilitates memory in longitudinal wave images and transverse waves. Implementing this TPCK strategy has the power and appeal to encourage active student-focused learning.

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